A COMPARATIVE RADIOGRAPHIC EVALUATION OF OCCLUSAL PLANE IN DENTULOUS AND EDENTULOUS SUBJECTS - A CLINICAL STUDY

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BRANCH VI

PROSTHODONTICS

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CERTIFICATE

This is to certify that this dissertation titled **"A COMPARATIVE RADIOGRAPHIC EVALUATION OF OCCLUSAL PLANE IN DENTULOUS AND EDENTULOUS SUBJECTS - A CLINICAL STUDY"** is a bonafide record of work done by **Dr. Singh Bishnupati** under our guidance and to our satisfaction during his postgraduate study period of 2005-2008.

This Dissertation is submitted to **THE TAMILNADU Dr. M.G.R. MEDICAL UNIVERSITY**, in partial fulfillment for the award of the Degree of **MASTER OF DENTAL SURGERY - PROSTHODONTICS, BRANCH VI.** It has not been submitted (partial or full) for the award of any other degree or diploma.

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Introduction

INTRODUCTION

Complete denture prosthodontics is the dental specialty which places a number of important factors in the control of the operator during the fabrication of complete denture prosthesis. The orientation of occlusal plane is one amongst them and is crucial in terms of function and esthetics.

Many authors have observed that the orientation of the occlusal plane may affect the denture function and that it is important to determine this orientation correctly in making comfortable dentures.[39] Most authors advice that artificial teeth should be placed in the positions previously occupied by the natural teeth.[35] This, therefore also includes the plane of occlusion. Studies have shown that the occlusal plane of artificial denture should be positioned at the same level as that in the natural dentition. [24]

The use of pre-extraction records to achieve the plane of occlusion in edentulous patients has been advocated for many years, with many methods proposed for making them. Among these methods are use of special gauges (e.g., Sorenson, [10] Willis, [63] Dakometer [14]) cardboard or wire profiles, [34, 53, 60]measurements from photographs, [53, 60, 65] measurement of the interfrenal distance, [58] measurement of the closest speaking space, [45] and use of a gauge oriented on the palate to reproduce tooth position.[18] However the use of these records for the orientation of occlusal plane in edentulous patients is not uniformly accepted.

In the absence of previous records, investigators [2,19,21] have suggested various concepts or methods for the orientation of the occlusal plane

based on morphologic studies on natural and artificial dentitions and also on clinical judgement.However, no one has shown an easy method for locating the occlusal plane correctly for every patient. This difficulty may be attributed to the lack of physiologic knowledge of occlusal plane orientation.

It is evident from the literature, that there is lack of consensus regarding the location of the occlusal plane in complete denture construction.[21, 51, 62] Many landmarks and techniques have been reported by various authors over the years for the location of the occlusal plane in edentulous patients. Some of these include, corner of the mouth and ear lobe – Gillis(1933); establishing the occlusal plane according to aesthetic requirements anteriorly and parallel to the ala-tragus line posteriorly (Craddock, 1951; Schlosser & Gehl, 1953), terminating the occlusal plane posteriorly at the middle or upper third of the retro molar pad (Boucher, 1964; Ismail & Bowman, 1968), and positioning the occlusal plane on the same level as the lateral border of the tongue (Yasaki, 1961; Ismail & Bowman, 1968).

However, the ala-tragus line (ATL) remains the most widely used and well documented guide for occlusal plane orientation and also the most commonly taught guide to the orientation of the occlusal plane.[25] It was also found that the tragus had several morphological variations and the middle of the tragus or the preciseness of superior border and inferior border was not always definable. Therefore its validity as a reference is questionable.[48]

The use of cephalometrics in Prosthodontics has been advocated in the past and its introduction into prosthetic treatment planning has become evident, and attempts have been made to establish cephalometric norms for occlusal plane

determination and evaluation.[31] However, its use in determining or evaluating the position and inclination of the occlusal plane has given conflicting results.[5] In contrast to this, Panoramic radiography is widely used and is often a tool used in routine dental examinations, especially for edentulous patients before the construction of a complete denture.[17] Moreover, literature regarding the use of OPG in determination or evaluation of occlusal plane in edentulous and dentulous patients is inadequate. It is unfortunate that no precise, scientific method exists for determining the level of the occlusal plane in edentulous patients. [36]

Wical and Swoope [61] in 1974 conducted a study to estimate the severity of the resorption of mandible, in which the mental foramen and the lower border of the mandible were used as reference points. In panoramic radiographs the constancy of their position irrespective of the duration of edentulousness and the amount of resorption attributed to the selection of these landmarks. The study concluded by establishing a ratio of 3:1 in the distance between the inferior border of the mandible to the crest of the residual ridge and the distance between inferior border of mandible and the lower edge of mental foramen in dentulous subjects to assess residual ridge resorption in edentulous patients.

It is well established in the literature, that these two reference points, namely inferior border of the mandible and the lower edge of the mental foramen are fairly constant in the position and proportion to each other. And also that these anatomic landmarks bear a constant proportion to the distances between the inferior border of the mandible and the crest of the alveolar bone.

The inferences drawn from Wical and Swoope study were utilized to carry out the present study. The aim of the present study was to establish a proportion between the inferior border of mandible and lower edge of the mental foramen and inferior border of mandible to occlusal plane for dentulous subjects and to evaluate the validity of this proportion in orienting the occlusal plane for edentulous subjects.

Also added to the aim were the following objectives:

1) To verify radiographically the occlusal plane existing in natural dentition and establishing the proportion in the distances between the lower edge of mental foramen to the inferior border of mandible and inferior border of mandible to the occlusal plane in dentulous subjects using panoramic radiographs.
2) To establish radiographically a proportion in the distances between lower edge of mental foramen to the inferior border of mandible and inferior border of mandible to the established occlusal plane in edentulous subjects using panoramic radiographs.
3) To compare and correlate the proportions obtained from dentulous subjects with that obtained from edentulous subjects.

Review of literature

REVIEW OF LITERATURE

L.E. Kurth (1940) [29] reviewed the literature on the posterior occlusal plane in full denture construction. He said that occlusal forces are different in dentulous and edentulous mouths. Therefore, what has been considered a normal arrangement of teeth in nature could be modified to suit individual edentulous need. The curve of Spee and its accompanying spherical theory of occlusion were shown neither to have a comparative anatomic background nor to afford a practical solution of the problem of occlusion in all cases. Non-anatomic teeth, such as the inverted cusp teeth, were a mechanical deviation to meet the changed conditions found in an edentulous mouth. Modifications of the transverse curve have been made for years. It was recommended that the curve of Spee be modified or eliminate to aid in retention in those cases wherein it was indicated.

The author believed that it was a step in the right direction to meet the individual needs in occlusion, rather than making an attempt to formulate a stereotyped "idealized" occlusion that meets the individual's needs.

Robert B. Sloane and Jack Cook (1953)[46] presented a guide to the orientation of the plane of occlusion based on a consideration of anatomic landmarks. The study was undertaken to determine whether or not there was any correlation between fixed cranial landmarks and the plane of occlusion. They studied twenty-six skulls. After marking the Frankfort plane, plane of occlusion and Cook's plane, the skulls were photographed. The distance between the plane of occlusion and certain fixed anatomical landmarks were

measured. The hamular notch and the anterior nasal spine were chosen since they are constant to both maxillary cast and the skull.

They concluded that there was apparently a relationship between fixed cranial landmarks that were common to both the skull and the edentulous upper cast. This relationship was sufficiently constant to allow the projection of the plane of occlusion when certain fundamental individual adjustments were incorporated into a mechanical device that correlates this basic relationship.

Russel H. Augsburger (1953)[2] studied the relationship between facial types and the location of the occlusal plane. Two hundred lateral cranial roentgen ray projections of senior dental students were studied to determine whether or not a correlation exists between facial type and occlusal plane location of natural dentitions. The Broad bent - Bolton Cephalostat and other well established methods were used in the study. Five facial types and seven angles were studied. On statistical evaluation, the majority of results came out as being statistically significant in 21 out of28 values measured.

The extremes of the occluso-Camper angle for the various facial types were given. In the bimaxillary protrusion cases, the angle formed with its apex to the anterior of the profile ranged from 2 degrees to 14 degrees. Mandibular retraction cases presented the apex of the angle located anteriorly ranging from 1 degree to 12 degrees. Maxillary protraction with mandibular retraction showed apices anterior reaching from 1 degree to 11 degrees. 1n the maxillary protraction group, the angle ranged from 1 degree to 13 degrees where all apices of angles located anterior to the profile. Mandibular retraction types showed all angles anterior to the profile reaching from 3 to 4 degrees.

The authors concluded that a strong correlation existed between the location of occlusal plane of natural dentition to given facial types in lateral aspect. Additional data obtained during the investigation revealed the location of the anterior teeth in relation to the occlusion plane according to facial type. The position of the tongue to the hard palate with the teeth in centric occlusion was also tallied.

Stanley G. Standard (1957) [52] described a method to establish the plane of occlusion during complete denture fabrication. This was done by means of wax occlusal rims constructed on stabilized base plates. The upper rim was placed in the mouth. The desired lengths of the central incisors were marked on the wax rim. Then Stenson's duct was marked on the wax with a hook explorer. At a point 6 mm downward toward the occlusal surface a line was marked up to the anterior region on both sides of the wax rims. Later the wax rim was reduced down to this line.

The wax rims were further modified till the plane was parallel anteroposterioly with the ala- tragus line and horizontally with the pupil of the eyes. With the completed upper wax rim in the mouth the physiologic rest position was recorded. The amount of freeway space desired was established. The lower wax rim was reduced to the tip of the retro molar pad Then the centric relation was established

Yahia H. Ismail and John F. Bowman (1968)[21] compared the positioning of the occlusal plane in natural and artificial teeth. A roentgenographic cephalometric investigation was conducted to compare the position of the occlusal plane of the artificial teeth with that of the natural teeth which existed before the remaining teeth were extracted. Twenty subjects comprising of 9 men and 11 women were studied. These were between 19 and 60 years of age and had a mean age of 41.5 years. Lateral cephalometric roentgenograms were obtained for the subjects with their natural teeth in centric

occlusion. Following removal of all teeth, complete denture fabrication was started within 9 to 12 weeks.

The occlusal plane of the trial dentures was oriented to parallel the ala-tragus line. The occlusal plane in the second molar region was adjusted so that it was at the level of the middle third of the retro molar pad. The finished complete dentures were inserted in patient's mouth and another series of roentgenograms were made for comparison. The location of the artificial occlusal plane was found to be at a lower level than the natural one in the posterior region.

So they suggested that the basic technique for orienting and positioning the occlusal plane in the posterior region for complete dentures should be modified by placing the second molars at the level of the upper third of the retro molar pad rather than the middle or lower third.

Donald O. Lundquist and Wallacce W. Luther (1970)[32] conducted an investigation to determine the accuracy of certain intraoral anatomic landmarks in predicting the location of occlusal plane. The relationship between the plane of occlusion and the retromo/ar pad, the parotid papilla, the buccinator grooves and the commissure of the lips was evaluated in 20 Caucasian subjects with ideal occlusions of natural teeth.

The investigations showed that the occlusal plane terminated in the area of the lower half of the retro molar pad in 75 percent of the subjects and in the other 25 percent, the plane terminated in the area of the upper half of the retro molar pad. The parotid papilla could assist in the determination of the vertical location of the plane of occlusion. However because of its variability it could only be classified as an aid and not as an accurate determinant. It was concluded that there was a close correlation between occlusal plane, the buccinator grooves and the commissure of the lips. Based on this a vestibular

impression technique was suggested for determining the location of the occlusal plane in completely edentulous patients.

Nikzad S. Javid (1974) [22] suggested a J-Shaped aluminum device, called a 'J' plane for use with a fox plane to establish the occlusal plane. When a complete denture is to be fabricated an accurate establishment of the occlusal plane in the upper occlusal rim is very important. It is difficult to establish a correct occlusal plane without using an extra device (tongue blade, ruler or the like).

The fox plane was held on the occlusal surface of the upper rim and J-plane against the nasion with its long axis passing through the interpupillary line to check anterior plane. Later the J-plane was held against the cheek, one side under the ala of the nose and the narrow part of it on the middle of the tragus to check posterior plane. The authors said that the J plane was a useful tool for accurately establishing the occlusal plane.

Kenneth E. Wical and Charles C. Swoope (1974) [61] studied the residual ridge resorption and use of panoramic radiographs for evaluation and classification of mandibular resorption. They described a method to estimate the severity of mandibular bone resorption by using the mental foramen and the inferior border of the mandible, as they appear in panoramic radiographs, as reference points.

Panoramic radiographs of 130 subjects were studied The authors concluded that, regardless of the usual magnification or distortion of the images, the lower edge of the mental foramen lies very close to a line dividing the mandible into thirds. By using the approximate ratio of 3: 1, the original height of the mandible could be estimated, that is the original height of the mandible is 3 times the distance from the lower border of the mandible to the lower edge of mental foramen. The amount of reduction in height of the alveolar bone was measured

It was suggested that this method of estimating and describing the degree of bone resorption might facilitate the study of the disease by providing an anatomic basis for classifying or grouping patients affected to varying degree.

Peter R.L' Estrange and Peter S. Vig (1975) [31] described a method to determine, the location of artificial teeth based on cephalometric criteria. The primary hypothesis in the study was that the angulation and vertical height of the occlusal plane were predictable from an assessment of the maxillomandibular space as seen on a lateral skull radiograph recorded with the opposing teeth in the intercuspal position.

The combination of height and length of the maxillomandibular space was a significant morphologic feature, and the maxillomandibular spaces were further subdivided into the categories of short and low, long and low, short and high and long and high.

The study was conducted in 26 dentulous and 26 edentulous subjects to determine the location of occlusal plane as related to the maxillomandibular space. The results from both the dentulous and edentulous groups indicated a close angular affinity between the occlusal plane and maxillary planes.

In the dentulous group, significant associations were found between the angulation of the occlusal plane and the height and length of the maxillomandibular space. The occlusal plane in the long- and -low type of maxillomandibular space tends to be more parallel to the maxillary plane, while the occlusal plane in the short- and - high type of maxillomandibular space tends to be more steeply angulated to the maxillary plane. The occlusal plane deviates away from a mean angulation to the maxillary plane when the height and length of the maxillomandibular space tend to be toward the opposite extreme of the normal range.

Hideaki Okane et al. (1979) [39] investigated the effect of anteroposterior inclination of the occlusal plane on muscle activity during clenching and biting force and to estimate physiologically the applicability of the ala-tragus line. The integrated electromyographic activity and biting forces of patients were examined at three different anteroposterior inclinations of the occlusal plane at a constant vertical dimension of occlusion. Four patients with complete dentures, three men and women, from 61 - 79 years of age, were selected.

Following conclusions were reached:

1. Biting force during maximum clenching was the greatest when the occlusal plane was made parallel to the ala-tragus line. It decreased when the occlusal plane was inclined about 5° anteriorly or about 5° posteriorly.

2. The efficiency of biting force exertion during maximum clenching showed the best value when the occlusal plane was made parallel to the ala-tragus line.

3. The muscle activity during clenching at various given forces was least when the occlusal plane was made parallel to the ala-tragus line.

The anteroposterior inclination of the occlusal plane showed to affect the biting force, and the method with the ala-tragus line seemed to be the most reasonable for occlusal plane orientation.

Martyn H. Spratley (1980) [51] described a simplified technique for determining the occlusal plane in full denture construction. The vertical level and angulation of the occlusal plane were discussed.

The upper occlusal plane was adjusted, so that, looking along the flats of the plane guide, it appeared to be at or just below the ear lobes. After the occlusal planes have been determined using this technique, a series of photographs of full face and profile, were

taken of the patients at the registration stage. The ala-tragus and interpupillary lines were marked on the prints, the occlusal plane being obvious from the fox guide. It was noticed that in the majority of cases a high degree of parallelism existed. Since the occlusal plane was judged by direct vision using easily recognizable reference points and there was no need to estimate parallelism, it was considered an excellent method particularly for teaching students.

H. Rich (1982) [42] conducted a study on evaluation and registration of the H.I.P plane of occlusion. The H.I.P plane can be defined as a plane extending from the hamular notches of the pterygoid hamulus to the incisive papilla. From these structures the abbreviation of-the H.I.P plane was derived.

Dental casts of Australian Aboriginal adults were used in the study. The relationship between the hamular notch- incisive papilla plane (H.I.P plane) and the occlusal plane of attrited dentitions was evaluated The H.I.P plane was easily established on any cast using the anatomical points of hamular notch and incisive papilla. It was found that in a considerable percentage of 32 casts, the H.I.P plane was closely correlated with the worn occlusal plane. Using the same reference points for 42 casts of edentulous maxillae, a close relationship between the H.I.P plane and the Frankfort plane was found.

David R. Williams (1982) [62] reviewed the various guides used to orient the occlusal plane in complete denture construction. The ala tragus line is the most commonly taught guide in orientation of the occlusal plane. Dentists attending the 19th Annual Conference of the British society for the study of prosthetic dentistry were invited to complete a short questionnaire and to draw, on a photograph, the ala tragus line (ATL).

Just over 50 percent of respondents stated that they always used the ATL as a guide. About one - third of these qualified their response by indicating that, although it was used

initially, the intra- oral morphology was the deciding factor in orienting the occlusal plane. Few used the retro molar pad as the guide. The residual ridges appear to be used more by dentists in the UK. As in the American, Canadian and Japanese surveys, the principal guide to occlusal plane orientation for complete dentures was the ATL. This for the majority of dentists in the UK meant from the lower border of the ala to the middle of the tragus. It would appear that, with increasing experience, there was less and less reliance on specific guides. There was rather a perception of"correctness" in the work. It was concluded that this element of complete denture construction owes less to the intelligent application of scientific principles than to a form of guesswork.

F. W Van Niekerk et al. (1985) [37] determined the relationship between the ala-tragus line, which runs from the inferior border of the ala of the nose to the inferior border of the tragus of the ear and an occlusal plane, established with the criteria that ignore the ala- tragus line during jaw registration procedures and the try in. Thirty three sets of complete dentures were made. Patients were completely satisfied with esthetic, function and comfort. A strip of foil taped to the face pointed at the inferior border of the ala and tragus. Lateral cephalometric radiographs were made of each patient. The relationship between the planes was measured and the angle between them was given a positive value for posterior convergence.

The occlusal plane of the dentures was checked against the ala tragus line. Results showed a close relationship between the two planes. The authors concluded that the ala-tragus line which runs from the inferior border of the ala of the nose to the inferior border of the tragus of the ear had a close relationship with the occlusal plane and could be used as a landmark when the maxillary occlusal rim was trimmed to the occlusal plane.

Brian D. Monteith (1985) [35] described a cephalometric method to determine the angulation of the occlusal plane in edentulous patients. The purpose of the study was to investigate the possibility of a correlation between the porion, nasion, anterior nasal spine (PoNANS) angle and the occlusal angle formed by the intersection of the occlusal and Frankfort planes. Lateral Cephalograms of 32 white women between 20 to 30 years of age were obtained and tracings were made.

The results of the study showed that an increase in the PoNANS angle has a flattening effect on the orientation of the occlusal plane, while a narrowing of the angle appears to force the occlusal plane into assuming a steeper attitude.

Louise Nilsson et al (1985) [38] *studied* the absorbed doses and energy imparted for the Orthopantomograph model OP 5 using two different collimators (0.9-1.3 X 33 mm^2 and 0.6-0.9 X 39.5 mm^2, respectively) were examined at 70 and 75 kV. The absorbed doses were estimated by thermo luminescence dosimetry in a sectioned phantom and by the energy imparted from measurements of areal exposure using a plane parallel transmission ionization chamber. The exposure distribution was surveyed on radiographic film. The anterior part of the parotid glands received the highest absorbed doses (2.4-3.2 mGy) when the wider collimator was used, with a decrease of two to three times when the narrower collimator was used. Other areas received absorbed doses of about 1.0 to 1.5 mGy or below. An increase of the k V from 70 to 75 had a minor influence. The energy imparted for the wider collimator was 0.6-0.8 and for the narrower collimator, 0.4-0.6 mJ.

Brian D. Monteith (1986) [36] gave a new concept in occlusal plane orientation for complete denture patients. The purpose of the study was to present an alternative method

of establishing the occlusal plane during complete denture fabrication. The proposed technique was based on statistically determined cephalometric criteria, and lends an element of precision and scientific method to an otherwise confused issue.

A lateral Cephalogram was obtained in the conventional way. A tracing was made to identify the porion, nasion and anterior nasal spine (ANS). These points were joined and the PoNANS angle thus formed was measured with a protractor. The following formula was used to compute the occlusal plane angle, Y'= 83.4307 - (0.9907. X). The PoNANS angle value obtained was substituted for X in the formula and solving the formula for Y' would provide the best computed value for the occlusal plane angle for the individual patient. The author said that the PoNANS angle analysis using the adjustable plane has been applied to complete denture fabrication for more than 1 year. The clinical results obtained were promising. Patient acceptance had· been generally enthusiastic, and it was never necessary to alter the occlusal plane orientation established by this method.

H. C Karkazis and G.L Polyzois (1987) [25] studied the location of the occlusal plane in complete denture fabrication. The authors conducted a cephalometric study: a) to determine the relationship between the natural occlusal plane and the Camper's plane. b) To determine the relationship between the established artificial occlusal plane in complete dentures and the Camper's plane. The study was carried out on eighteen dentulous subjects and fifty - six complete denture wearers. The occlusal plane and Camper's plane were traced on the lateral cephalograms. The deviation between the two planes was measured.

The results of the study indicated that both the natural and artificial occlusal planes were not parallel to Camper's plane. However, the final anteroposterior inclination of the

artificial occlusal plane in complete dentures was almost the same as the inclination of the natural occlusal plane.

G. V. Packota, J.N. Hoover and B.D. Neufeld (1988) [40] described a method of estimating alveolar bone height for both the maxilla and mandible in the form of ratio using normal anatomic landmarks visualized on panoramic radiographs. Measurements were performed on four different types of panoramic radiographs. Results determined for the maxillae and mandible was constant between the different types of panoramic films. The ratios could be compared with similarly obtained data in clinical or radiographic studies in which alveolar bone loss or atrophy had occurred.

They concluded that, this method could prove valuable in serial studies where alveolar bone height for a single patient had occurred at different times before and after tooth loss.

Takashi Yosue, Sharon L. Brooks (1989) [70] analyzed the appearance of mental foramina on panoramic radiographs. They analyzed all panoramic radiographs taken of patients at the University Michigan School of dentistry during a 4- month period.

The following conclusions were drawn:

1. The appearance of mental foramina on panoramic radiographs can be divided into four types: continuous (21%), separated (43%), diffuse (24%), and unidentified (12%).

2. The most frequent appearance of the mental foramen was the "separated type," whereas the numbers of "continuous type" and "diffuse type" were almost the same.

3. The reasons for the absence of mental foramina on panoramic radiographs include superimpositions of tooth buds in mixed dentition radiographs, inability to distinguish from the trabecular pattern in complete dentition radiographs, thin mandibular bone in edentulous radiographs and overly dark radiographs.

4. The vertical position of mental foramina on the panoramic radiographs of "incomplete dentition group" was similar to that of "complete dentition group".

5. It was strongly suspected that sometimes the radiographic landmark of what was described as the mental foramen was actually a section of the mental canal.

Takashi Yosue, Sharon L. Brooks (1989) [69] experimentally evaluated the appearance of mental foramina on panoramic and Periapical radiographs. The image of the mental foramen was studied on panoramic and Periapical radiographs of four dry skulls (an infant, a teenager, an adult male and an adult female) with a variety of vertical and horizontal angulations, skull positions, and exposure times. It was found that any change in exposure conditions affected both the type of appearance (continuous, diffuse or unidentified) and the relative vertical position of the foramen. The radiographic position agreed with the actual position in less than half the time regardless of technique, although the apparent diameter of the foramen was close to the true diameter.

The following conclusions were drawn:

a. The mental foramen appeared more consistently on panoramic than on Periapical radiographs.

b) On panoramic radiographs, the appearance of the mental foramen changed with the positioning of the mandible where as on Periapical radiographs, it changed with the vertical and horizontal angulation of x-ray equipment.

c). Increased film density increased the difficulty in detecting the mental foramen.

d).It was suspected that the radiographic landmark called "mental foramen" on panoramic or Periapical radiographs was not the true mental foramen but rather a portion of the mental canal after it leaves the mandibular canal.

e).Although the radiographic diameters of metal foramina change according to the positioning of dry skulls and angulation of X-ray equipment, they are similar to the true value.

John L. Phillips, R. Norman Weller and James C. Kulild (1990) [41] studied the size and orientation of the mental foramen as well as its Positional relationships to the mandibular second premolar.

Seventy-five adult human mandibles were examined. The average size of the foramen was found to be larger on the left side of the mandible and its usual direction of exit was in a posterior superior direction. The most common location of the mental foramen was inferior to the crown of the second premolar and approximately 60% of the distance from the buccal cusp tip of that tooth to the inferior border of the mandible.

H. Tal and O. Moses (1991) [54] studied the accuracy of panoramic radiography and computed tomography (CT) in the evaluation of depth of the mandible at recipient implant sites was compared by measuring the distance between the edentulous bony crest and the superior border of the inferior alveolar canal in a group of ten patients. Distortion was calculated using the metal ball technique for the panoramic radiographs and the computer scale for the CT scans. The precise distance between the bony crest and inferior alveolar canal was determined from postoperative radiographs from the known length of the implants. It was found that although CT scans are more precise. Panoramic radiography is sufficiently accurate for routine clinical purposes.

Altug Kazanoglu and John W. Unger (1992) [26] used a device called Camper's plane indicator for establishing plane of occlusion in complete dentures. The device was simple, practical and accurate with all the necessary parts assembled in one instrument.

The maxillary occlusal rim was adjusted to the proper length and fullness anteriorly for esthetic requirements. The intraoral part of the lower plate of the Camper's plane indicator was placed against the occlusal surfaces of the maxillary occlusal rim. The upper plate moved up and down until it was on Camper's plane. If the occlusal rim was not made parallel with Camper's plane, the upper plate would not lie on a line from the ala of the nose to the tragus of the ear. This technique would easily determine whether the plane of occlusion of the maxillary rim was parallel with Camper's plane. It also indicated whether the anterior occlusion rim was parallel with the patient's interpupillary line.

The authors said that it was easy to use the plane indicator when the plane of occlusion of edentulous patients was to be made parallel with Camper's plane.

M.M Koller et al (1992) [28] compared two methods to orient the occlusal plane (OP) and to determine the vertical dimension of occlusion (VDO). In method A the VDO was established by means of the rest position, the minimal speaking distance, and the patient's profile. Method B used a newly developed registration pin assembly. The VDO was registered using a silicone occlusion rim and the swallowing technique. The results were compared to the values of-the new dentures.

Three standardized lateral radiographs were taken at the VDO obtained with methods A, B, and at that of the final dentures. On each radiograph the orientation of the OP to the Camper plane and the VDO were measured by two investigators independently. The results indicated no statistically significant differences between the mean VDO with method A and B compared with the new dentures *(P> 0·05).*

With both methods it was not possible to orientate the OP parallel to the Camper plane. None of the occlusal planes of the new dentures were parallel either. Their OP diverged on average by 7° dorso-caudally.

The time spent with method B to orient the OP and to determine the VDO was significantly lower' than with method A (17-50 min).

Q Xie et al., (1996) [66] described the effect of head positioning in panoramic radiography on vertical measurements. The study was carried out to assess whether it was possible to make accurate vertical measurements of the jaws from panoramic radiographs. Five dry skulls were shifted 5 mm forward and backward and tilted 5° up and down in the sagittal plane. Panoramic radiographs of each skull were obtained in nine different positions. In the maxilla, three reference lines were used and vertical measurements were made at distal surface of the first premolar and first molar and in the midline. In the mandible, measurements were made at the distal surfaces of the first premolar and first molar, and at the mental foramen on both sides, and in the midline. The points and lines were marked manually and the radiographs were digitized, magnified and measured.

Results of the study showed that the sagittal shifting and tilting had only a slight effect on measurements in the mandible. Sagittal tilting of the head had the greatest effect on all the measurements made from the line between the articular eminences to the alveolar crest, as well as measurements in the maxillary midline.

The authors concluded that the line between the articular eminences were unsuitable as a reference line for measurements of the tooth- bearing areas. A slight misalignment of the head did not significantly affect the vertical measurements in the mandible or of the posterior maxilla if reference lines were in the same vertical plane as the teeth.

Qiufei Xie et al, (1996) [67] studied the height of mandibular basal bone in dentate and edentulous subjects. The study was to discover whether any difference existed in the height of the mandibular basal bone between young and old subjects and to assess the

basal bone in edentulous subjects in comparison with that of dentate subjects. Two groups of dentate subjects, .young and old, and one group of edentulous elderly subjects were examined. The panoramic radiographs of the subjects were taken. The distances of the mental foramen and mandibular canal from the lower border of the mandible, when measured, showed that the mandibular basal bones in old dentate and in old edentulous men to be higher than those of young dentate men in the molar region. The height of the basal bone below the mental foramen was smaller in old edentulous women than in young and old dentate women.

Authors concluded that slight bone deposition seemed to occur along the lower border of the mandible in the molar region with age in contemporary people, particularly in men. The mental foramina of edentulous women moved toward the lower border of the mandible as a result of alveolar bone resorption.

Neena L. D'Souza and Kashyap Bhargava (1996) [12] conducted a cephalometric study to compare the occlusal plane in dentulous and edentulous subjects in relation to the maxillo-mandibular space. They examined the validity of Camper's plane as a guide to determine the occlusal plane in edentulous subjects. In this study the occlusal plane was established to be parallel to Camper's plane. Right cephalograms of 40 dentulous and edentulous subjects were taken. A comparison of the natural occlusal plane in dentulous subjects and the artificial occlusal plane in edentulous patients was then made cephalometrically based on the dimensions of the maxillo-mandibular space, namely, height and length and maxillo-mandibular angle. Based on the data collected from the cephalometric tracings and with the use the significant correlations of the variables of maxillo-mandibular space established, both the groups were classified into four sub-divisions according to length and maxillomandibular angle. The occlusal

plane/maxillary plane angles and the occlusal plane/ mandibular plane angles were then compared.

On comparison of the occlusal plane, the results obtained demonstrated a similar pattern within the groups within probable limits. With respect to occlusal and maxillary plane angulation, neither the dentulous nor edentulous groups varied significantly in their values of this angle within the groups. However, the occlusal and maxillary plane angulations in the edentulous groups were higher than that of the dentulous group, probably because the established occlusal plane was placed at a higher level posteriorly.

Dr. E G.R. Solomon et al. (2000) [48] conducted an investigation to study the anatomical features, variations and the location of various landmarks of tragus to ala-tragal line in view of its Importance as a useful reference in establishing Camper's plane. 2048 tragi forms were studied, in subjects within 18-25 years age group comprising of both sexes. Besides the shape of the tragus, the preciseness of the superior border, middle and inferior border of the tragus were studied, as these landmarks have been recommended as references to form the ala- tragus line/plane. It was found that the tragus had several morphologic variations and it was classified as typical pointed, rounded, notched and rudimentary tragus. The middle of tragus was definable only in typical pointed tragus. The preciseness of superior border and inferior border was not always definable. Therefore its validity as a reference was questionable. Camper's plane was found to be parallel to the occlusal plane when the tragal reference point was situated between the superior border and the middle of the tragus and not from the usual hitherto recommended reference point

A.U. GULER et al (2005) [17] conducted a study to determine variations in the vertical height measurements in the edentulous maxilla and mandible, and to assess

positions of the maxillary sinus, mandibular foramen, and the mandibular canal, which are important for implant length selection and planning using panoramic radiographs. The study sample included 346 edentulous alveolar ridges of 90 men and 83 women. Sixty-three dentate patients' panoramic radiographs were used for location of the first premolar and molar area. Panoramic radiographs were made with a Siemens Orthophos panoramic machine which had been standardized previously. All radiographs were made using a standardized manner by the same technician. Fourteen sites were measured on every panoramic radiograph whenever possible, eight sites in the maxilla and six sites in the mandible. Correlation analyses were performed between age groups and all measurements to determine if age is significant as a covariate. In order to examine the effect of gender the statistical analysis of differences between men and women was performed with Student t-test. The 5% significance level was used for statistical significancy. The height of the maxilla and the mandible in the anterior, first premolar, and first molar regions were significantly greater in men than in women. A majority of the most inferior border of the maxillary sinuses was located anterior to the first molar area (premolar regions) both in men (48'9%) and women (55'4%). Although, there was no statistically significant difference between edentulous men and women for the vertical distances from the mental foramen to the alveolar crest, and horizontal distances from mental foramen to midline, there were statistically significant differences between edentulous men and edentulous women for the vertical distances from the upper border of the mandibular canal to the alveolar crest in the first molar area. Mental foramens were located at the crest of the ridge in 7'2% of the edentulous women, and 6'7% of the edentulous men. The results of this study may guide clinicians to make primer decision of implant insertion area for implant supported prosthesis in edentulous patients.

Materials and Method

MATERIALS AND METHOD

One of the fundamental requirements in complete denture fabrication is the accurate establishment of the plane of occlusion. The precise location of the occlusal plane for edentulous patients is a controversial matter. There appears to be a lack of agreement on its orientation for individual patients. Various authors advocated a wide variety of landmarks and techniques. However no single method seems to be fully accepted.

The following materials were used for the present study:

1) Dental stone (Asian chemicals, Rajkot, Gujrat, India)
2) Cold cure denture base resin(DPI- RR cold cure, Dental products India Ltd, Mumbai, India) (Fig 1)
3) Modelling wax(INDU, Chennai, India) (Fig 2)
4) Fox plane (Fig 3)
5) 23 gauge stainless steel wire(Konark, S.S wire, India) (Fig 4)
6) Radiographic film (Kodak film, Kodak India Pvt. Ltd.) (Fig 5)
7) Acetate paper (Fig 6)
8) HB tipped pencil (Fig 7 a)

Equipment and instruments used in the study:

1. OPG radiographic machine(X-MIND, SATELEC, GERMANY)(Fig 8)
2. X-RAY Viewer (Fig 9)
3. Millimeter ruler to an accuracy of 0.5 mm(Real, India) (Fig 7b)

Methodology

The methodology for the present study included the following phases:

I. Selection of subjects.

a) Dentulous

b) Edentulous

II. Occlusal plane determination for edentulous subjects

a) Fabrication of occlusal rims.

b) Orientation of occlusal plane.

c) Attachment of radiopaque marker.

III. Obtaining panoramic radiographs.

a) Dentulous subjects

b) Edentulous subjects

IV. Tracing the panoramic radiographs.

a) Dentulous subjects: Occlusal plane determination for dentulous subjects

b) Edentulous subjects

V. Measurement of the reference points.

a) Dentulous subjects

b) Edentulous subjects

VI. Interpretation of measurements.

VII. Tabulation of results.

I Selection of subjects:

In the present study fifty (50) dentulous and (50) edentulous subjects were selected from the out patient clinic of the Department of Prosthodontics of Ragas Dental College and Hospital, Chennai. Equal numbers of male and female subjects were selected in both the dentulous and edentulous subjects. An informed consent was obtained from the subjects regarding their participation in the study.

a) Criteria employed for the selection of dentulous subjects:

a) Normal healthy, dentate subjects within the age group of 21 to 25 were selected for the study.

b) Mandibular premolars and first molars were present and mandibular molars were in Angle's class 1 relationship.

c) Although the occlusion in all subjects did not conform to the textbook ideal, all were considered acceptable.

d) Selected subjects were free of temporomandibular joint disorders.

e) Subjects had sound neuromuscular control.

f) Dentulous subjects who have undergone orthodontic treatment were not selected for the study.

b) Criteria employed for the selection of edentulous subjects:

a) Normal healthy, completely edentulous patients within the age group of 50 to 70 years were selected for the study.

b) Subjects did not have any systemic or debilitating diseases.

c) Subjects with acceptable neuromuscular control.

d) Subjects did not have any temporomandibular joint disorders.

II Occlusal plane determination for edentulous subjects:

a) Fabrication of occlusal rims:

Maxillary and mandibular final impressions were made and master casts were obtained in dental stone (Asian chemicals, Rajkot, Gujarat, India). The base of the cast was made parallel to the residual ridge with the help of a model trimmer. Undercuts were blocked, and record bases were prepared in autopolymerising acrylic resin (DPI – RR cold cure, Dental products India Ltd, Mumbai, India) which was allowed to polymerize in a water bath at 37^0C for 15 minutes. The record bases were separated from the cast, and were finished and polished.

A sheet of base plate wax (Indu Modelling Wax, Chennai, India.)was heated over the flame of Bunsen burner to approximately one half its length until the wax was soft and pliable. Care was taken not to melt the wax completely. The soft wax was rolled to a point just short of the unheated area. The wax was again heated to include two thirds of the previously unheated wax; it was then rolled, and the process was repeated again until a soft roll was formed. The soft wax roll was adapted to the recording base. The roll was further sealed to the base, using a wax spatula with additional molten wax. A heated broad blade knife was used to shape the labial surface of the occlusal rim. The anterior surface was made to incline outward, while the posterior surface was sloped slightly inward. A hot wax spatula was used to smooth the lingual surface and form a rim

approximately 5 mm wide in the anterior area and approximately 8 to 10 mm in the posterior area. The anterior vertical height of the maxillary rim was adjusted to approximately 22 mm from the reflection of the cast. The posterior height was fabricated to equal the approximate length of the first maxillary molar crown. A slightly different vertical height was applied to the mandibular rim. An anterior height of approximately 16 mm was used, while in the posterior region the height was equal to a point representing one half the height of the retromolar pad. The width of the mandibular rim in the anterior area was approximately 5mm and in the posterior approximately 8 to 10 mm. (Fig10)

b) Orientation of occlusal plane:

The prepared maxillary occlusal rim was placed in the patient's mouth and adjusted to obtain adequate labial fullness and lip support. Then the anterior occlusal plane was established by maintaining it parallel to the interpupillary line and placing it 2 to 3 mm visible when the patient talked and smiled. (Fig 11&12) Next, the posterior occlusal plane was established by maintaining it parallel to the ala tragus line, which in this study was considered at the junction of superior and middle part of tragus of the ear to the lower border of ala of nose. A fox plane was used to confirm the parallelism of the maxillary occlusal rim to the Camper's plane. (Fig13&14) With the completed upper occlusal rim placed in the patient's mouth, the physiologic rest position was determined. The lower occlusal rim was adjusted so that the amount of freeway space was 2-3 mm.The same procedure was followed for all the edentulous subjects included in this study.

c) Attachment of radiopaque marker:

After the occlusal plane was established, a 23 gauge stainless steel wire (Konark, S.S wire, India) was shaped to the form of lower occlusal rim. The wire was accurately adapted on the occlusal plane of the lower occlusal rim and was stabilized by the addition of a thin layer of wax. Due to the radio opacity of the S.S. wire, the occlusal plane could be easily demarcated and traced in the panoramic radiographs. (Fig 15)

III Obtaining the radiographs:

The method followed in this study to obtain the panoramic radiographs for dentulous and edentulous subjects was based on the method followed by Wical and Swoope in their study. Panoramic radiographs for this study were obtained from (X-MIND, SATELEC, Germany), using radiographic film (Kodak 30/15 film, KODAK INDIA PVT. LTD., Mumbai, India) in the Department of Oral Medicine and Radiology, Ragas Dental College and Hospital. Prior to obtaining the panoramic radiographs, both the dentulous and edentulous subjects included in this study were asked to remove jewellery, hair-pins, and any other metallic objects in the head and neck region to prevent the superimposition of their images on the images of important anatomical landmarks and other reference points included in this study.

a) Procedure for dentulous subjects:

Panoramic radiographs (X-MIND, SATELEC, Germany) were obtained of the selected dentulous subjects using suitable film (Kodak 30/15 film, KODAK INDIA PVT. LTD., Mumbai, India). (Fig 16)

Patient positioning was in strict adherence with the manufacturer's manual as it varies from one machine to another.[1]After proper positioning of the subjects the dentulous subjects were asked to place the incisal edges of their maxillary and mandibular incisors into a notched positioning device (the bite block). Then the x-ray beam was projected. The average exposure time at 70-75 kVp and 8-9 mA using fast speed films was 14 seconds. The panoramic radiographs were immediately developed and checked. In case of any error or a poor radiograph, the panoramic radiograph was remade. (Fig18)

The same procedure as described above was followed for all the fifty dentulous subjects included in this study. Thus a total of fifty panoramic radiographs were obtained of the selected subjects and were dried and labeled for future reference and kept aside

b) Procedure for edentulous subjects:

Panoramic radiographs (X-MIND, SATELEC, Germany) were obtained of the selected edentulous subjects using suitable film (Kodak 30/15 film, KODAK INDIA PVT. LTD., Mumbai, India) (Fig17)

The same procedures as described above for the dentulous subjects were followed prior to obtaining the panoramic radiographs of the edentulous subjects. Panoramic radiographs of the edentulous subjects were made with the occlusal rims in their mouth to which radiopaque marker was attached for easy demarcation of the occlusal plane. The subjects were guided to bite gently in centric relation and maintain the constancy in their position while the radiographs were made.

Then the x-ray beam was projected. The average exposure time at 70-75 kVp and 8-9 mA using fast speed films was 14 seconds. The panoramic radiographs were immediately developed and checked. In case of any error or a poor radiograph, the panoramic radiograph was remade. (Fig19)

The same procedure as described above was followed for all the fifty edentulous subjects included in this study. Thus a total of fifty panoramic radiographs were obtained of the selected subjects and were dried and labeled for future reference.

IV Tracing the panoramic radiographs:

Occlusal plane determination for dentulous subjects:

In dentulous subjects the lower occlusal plane was considered at the cusp tip of the mandibular second premolar. The second premolar was selected as reference tooth based on the findings of a study conducted for the size, orientation, and positional relationship to the mandibular second premolar by John. L. Phillips et al [41] and the buccal cusp tip was chosen as a reference point to facilitate vertical linear measurements with maximum accuracy as suggested by Q.Xie et al.[66] (Fig18)

The method of tracing the panoramic radiograph to outline the selected reference points and to obtain the distances between the selected reference points included in this study was based on the method followed by Wical and Swoope[61] in their study.

The panoramic radiographs were traced in the following step by step procedure:

Step 1- Tracing the dentulous panoramic radiograph:

- The panoramic radiograph of the dentulous subject was placed on an "X-Ray viewer" and three widely separated re-orientation marks were placed on them.

- An acetate paper was taken and attached to the panoramic radiograph.

- With the help of the" X-Ray Viewer", the three re-orientation marks and the main landmarks namely the mandibular canal, mental foramen, the inferior border of the mandible and the occlusal plane depicted by the cusp tip of the mandibular second premolar were outlined on both right and left sides of the acetate paper using a HB tipped pencil. Thus the tracing of the dentulous panoramic radiograph was completed in this manner.
- The same procedure for tracing the panoramic radiographs was followed for all of the selected fifty dentulous subjects. (Fig20)

Step 2- Tracing the edentulous panoramic radiograph:

- The panoramic radiograph of the edentulous subject was placed on an "X-Ray viewer" and three widely separated re-orientation marks were placed on them.
- An acetate paper was taken and attached to the panoramic radiograph.
- With the help of the" X-Ray Viewer", the three re-orientation marks and the main landmarks namely the mandibular canal, mental foramen, the inferior border of the mandible and the occlusal plane depicted by the Konark S.S. Dental wire were outlined on both right and left sides of the acetate paper using a HB tipped pencil. Thus the tracing of the edentulous panoramic radiograph was completed in this manner.
- The same procedure for tracing the panoramic radiographs was followed for all of the selected fifty edentulous subjects. (Fig21)

V Measurement of the reference points:

The measurements of the reference points outlined in this study were done in accordance with the criteria followed by Wical and Swoope [61], Takashi Yosue and Sharon L. Brooks [70], and A.U. Guler et al [17] in their respective studies.

a) Procedure for dentulous subjects:

After obtaining the tracings of the panoramic radiographs of selected dentulous subjects included in this study on the acetate paper, the selected reference points were marked using HB tipped pencil in the following manner:

- Point A: Point on the inferior border of the mandible in line with the mental foramen.

- Point B: Point on the lower edge of the mental foramen.
- Point C: Point on the occlusal plane (cusp tip of the mandibular second premolar) in line with the mental foramen.
- The selected reference points, namely A, B, and C were joined by a straight line on the acetate paper to aid in the linear measurement of distances between the reference points. (Fig20) All measurements were in MM.
- The same procedure for outlining and measuring the distances between the reference points was followed on the right as well as on the left side of the panoramic radiographs.
- The above mentioned procedure for the measurement of distances between the reference points was followed for all of the selected fifty dentulous subjects

b) Procedure for edentulous subjects:

After obtaining the tracings of the panoramic radiographs of selected edentulous subjects included in this study on the acetate paper, the selected reference points were marked using HB tipped pencil in the following manner:

- Point A': Point on the inferior border of the mandible in line with the mental foramen.
- Point B': Point on the lower edge of the mental foramen.
- Point C': Point on the occlusal plane (as depicted by the Konark stainless steel wire attached to the mandibular occlusal rim) in line with the mental foramen.
- The selected reference points namely A', B', and C' were joined by a straight line on the acetate paper to aid in the linear measurement of distances between the reference points. (Fig21)All measurements were in MM.
- The same procedure for outlining and measuring the distances between the reference points was followed on the right as well as on the left side of the panoramic radiographs.
- The above mentioned procedure for the measurement of distances between the reference points was followed for all of the selected fifty edentulous subjects.

VI Interpretation of measurements:

The acetate paper with the outlined reference points of all the selected subjects (50 dentulous and 50 edentulous) were subjected to mathematical interpretation to arrive at a proportion between the reference points.

- The distances between AB, AC, A'B'and A'C' were measured on both right and left sides of the selected dentulous and edentulous subjects.
- The right and left values were taken as average for all the measurements in one subject.
- The proportion for the distances between AB and AC was obtained.
- Similarly the proportioning for the distances between A'B' and A'C' was obtained.
- Both the obtained proportions were compared.
- The same procedure was followed for all the fifty dentulous and fifty edentulous subjects selected for this study

VII Tabulation of results:

The results obtained from this study were tabulated under various headings for statistical analysis and interpretation. To facilitate inter and intra group comparisons, necessary subdivisions were made.

Figures

Fig 1: Autopolymerizing acrylic resin

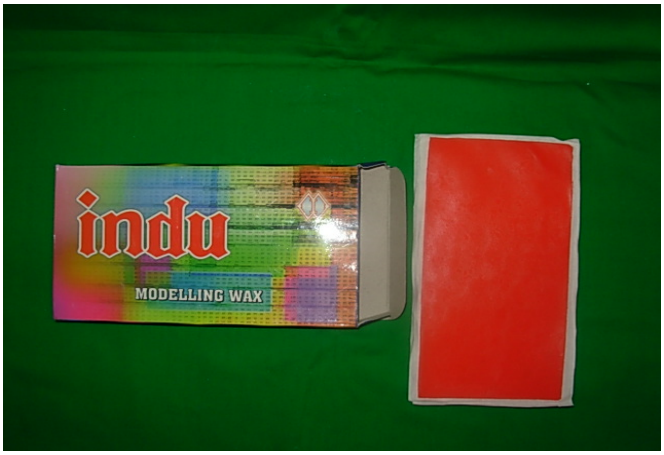


Fig 2: Modelling wax

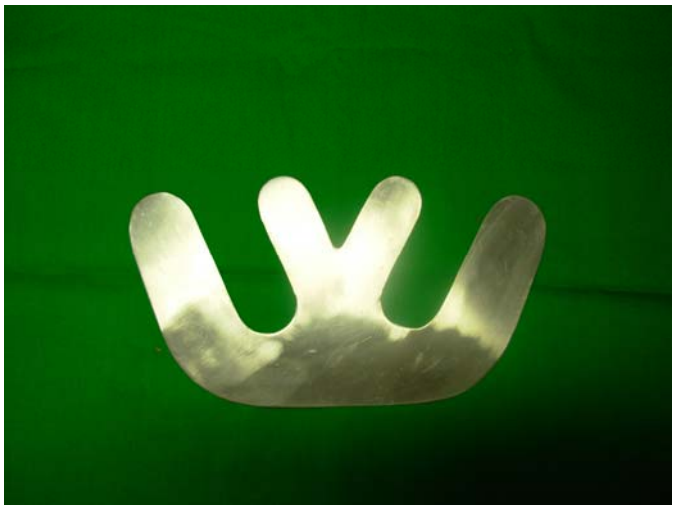


Fig 3: Fox plane

Fig 4: Stainless steel wire

Fig 5: Radiographic film

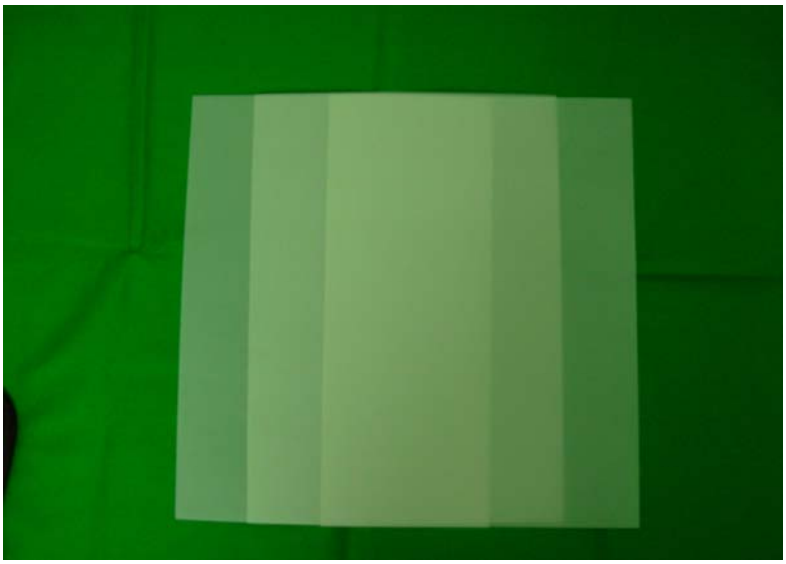


Fig 6: Acetate paper

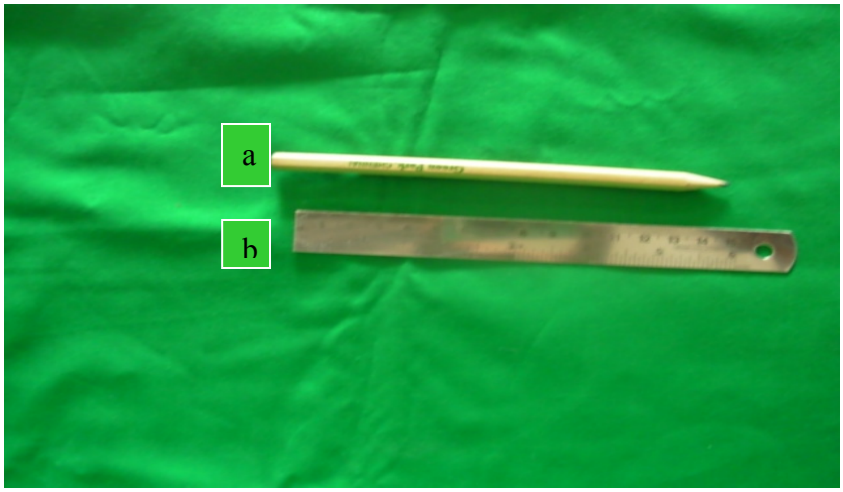


Fig 7: a - HB Tipped Pencil
b - Millimeter Ruler

Fig 8: OPG radiographic machine

Fig 9: X-Ray Viewer

Fig 10: Fabricated occlusal rims for establishing the occlusal plane

Fig 11: Maxillary anterior occlusal plane verified for visibility and labial fullness

Fig 12: Verifying the parallelism of the maxillary anterior occlusal plane with the interpupillary line

Fig 13: Verifying the parallelism of the maxillary posterior occlusal plane to the ala-tragus line using fox plane. (Right lateral view)

Fig 14: Verifying the parallelism of the maxillary posterior occlusal plane to the ala-tragus line using fox plane. (Left lateral view)

Fig 15: Stainless steel wire attached to the lower occlusal rim

Fig 16: Obtaining the panoramic radiograph of the dentulous subject

Fig 17: Obtaining the panoramic radiograph of the edentulous subject.

Fig 18: Panoramic radiograph of the dentulous subject

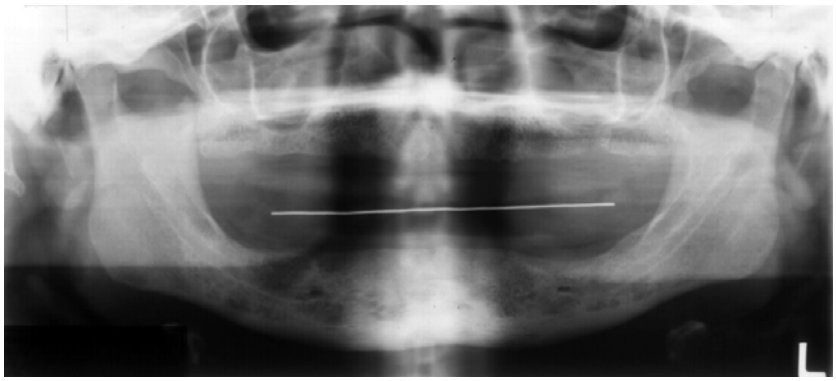


Fig 19: Panoramic radiograph of the edentulous subject

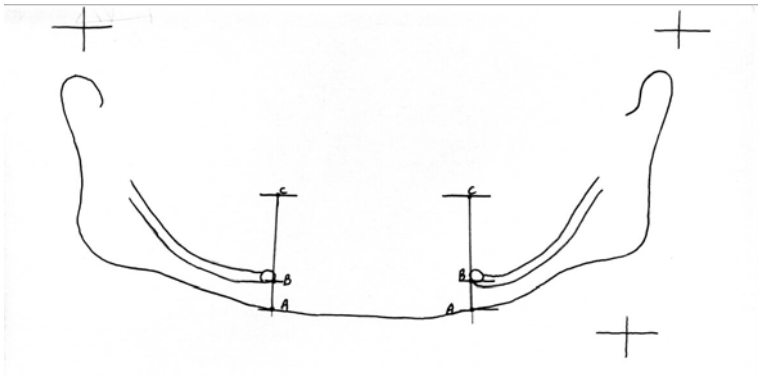


Fig 20: Tracing of the dentulous panoramic radiograph

KEY:

- Point A: Point on inferior border of mandible in line with mental foramen.
- Point B: Point on lower edge of mental foramen.
- Point C: Point on occlusal plane (cusp tip of the mandibular second premolar) in line with mental foramen.
- +: re-orientation marks

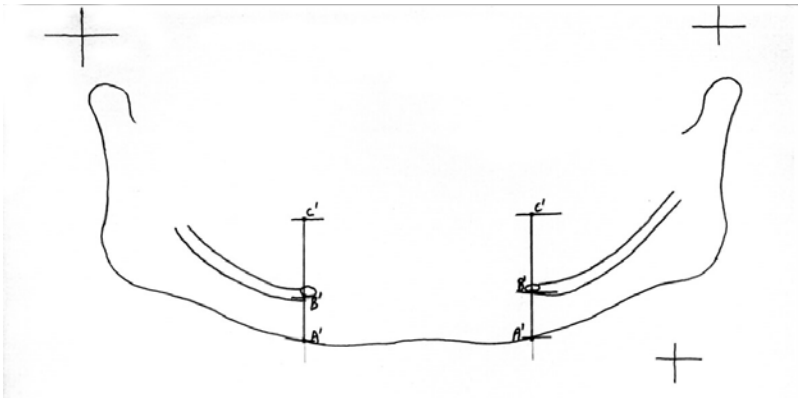


Fig21: Tracing of the edentulous panoramic radiograph

KEY:

- Point A': Point on inferior border of mandible in line with mental foramen.
- Point B': Point on lower edge of mental foramen.
- Point C': Point on occlusal plane (cusp tip of the mandibular second premolar) in line with mental foramen.
- +: re-orientation marks

Results

RESULTS

The following results were drawn from the study, which compared the proportion in the distances between lower edge of mental foramen to the inferior border of the mandible and inferior border of mandible to the occlusal plane in dentulous and edentulous subjects.

AB is the distance between the inferior border of mandible to the lower edge of mental foramen in dentulous subjects.
AC is the distance between the inferior border of mandible to the occlusal plane in dentulous subjects.
A'B' and A'C' were the name given to the same distances in edentulous subjects

After measuring the distances, the proportion between the distances was determined. The mean proportion of dentulous, edentulous, male and female subjects were evaluated Then the proportion of male subjects was compared with that of female subjects and dentulous subjects with that of edentulous subjects

Comparison of proportion between the different groups was done by using unpaired t-test. The Mean and Standard Deviation (SD) were determined for each group separately and were compared within each group.
X_1- mean proportion of one (dentulous /male/female) group.
X_2-mean proportion of another (edentulous/male/female) group

$$t = \frac{\bar{X}_1 - \bar{X}_2}{\text{Std. error of difference (SE)}}$$

$$SE = \frac{SD}{\sqrt{n}}$$

From the calculated't' value 'p' - probability for error was found out.

Table - I & II show the individual measurements of male and female dentulous subjects.

Table - III & IV show the individual measurements of male and female edentulous subjects.

Table - V shows the comparison of fifty dentulous and fifty edentulous subjects. In dentulous subjects the proportion ranged from 1: 3.53 to 1: 4.40. The mean was 1: 3.90. In edentulous subjects the proportion ranged from 1:3.50 to 1:4.15. The mean was 1:3.84. On comparison the difference between both the groups was 0.06. The difference was statistically insignificant (P=0.14).

Table -VI. Shows the comparison of twenty -five dentulous and twenty-five edentulous male subjects. In dentulous male subjects the proportion ranged from 1:3.53 to 1:4.40. The mean was 1:3.89. In edentulous male subjects the proportion ranged from 1: 3. 50 to 1:4.15. The mean was 1: 3.84. On comparison the difference between both the groups was 0.05. The difference was statistically insignificant (P = 0.24).

Table - VII. Shows the comparison of twenty-five dentulous and twenty-five edentulous female subjects. In dentulous female subjects the proportion ranged from 1:3.58 to 1:4.40. The mean was 1:3.91. In edentulous female subjects the proportion ranged from 1:3.55 to 1:4.10. The mean was 1:3.87. On comparison the difference between both the groups was 0.04. The difference was statistically insignificant (P=0.36).

Table - VIII. Shows the comparison of dentulous male and female subjects. The difference obtained was 0.02. The difference was statistically insignificant (P=O. 77).

Table - IX .Shows the comparison of edentulous male and female subjects. The difference obtained was 0.03. The difference was statistically insignificant (P=0.51).

TABLE- I

Basic data showing the measurements derived from radiographs of dentulous subjects - males

NO.	MEASUREMENTS						
	RIGHT		Proportion	LEFT		Proportion	AVERAGE PROPORTION
	AB	AC	AB:AC	AB	AC	AB:AC	
1.	13	50	1:3.84	13	50	1:3.84	1:3.84
2.	13	50	1:3.84	13	50	1:3.84	1:3.84
3.	13	47	1:3.61	11	46	1:4.18	1:3.89
4.	14	54	1:3.85	13	53	1:4.07	1:3.95
5.	10	44	1:4.4	10	44	1:4.4	1:4.4
6.	14	55	1:3.92	14	55	1:3.92	1:3.92
7.	12	47	1:3.91	12	48	1:4	1:3.95
8.	13	49	1:3.76	13	48	1:3.69	1:3.75
9.	14	54	1:3.85	13	53	1:4.07	1:3.95
10.	14	52	1:3.71	14	49	1:3.50	1:3.60
11.	15	56	1:3.73	15	56	1:3.73	1:3.73
12.	13	48	1:3.69	11	47	1:4.27	1:4
13.	13	50	1:3.84	14	54	1:3.85	1:3.84
14.	13	46	1:3.53	13	46	1:3.53	1:3.53
15.	13	52	1:4	13	51	1:3.92	1:3.95
16.	13	51	1:3.92	13	50	1:3.84	1:3.85
17.	13	48	1:3.69	13	49	1:3.76	1:3.75
18.	13	54	1:4.15	13	51	1:3.92	1:4
19.	12	46	1:3.83	11	45	1:4.09	1:3.96
20.	12	47	1:3.91	12	47	1:3.91	1:3.91
21.	12	46	1:3.83	12	45	1:3.78	1:3.80
22.	14	53	1:3.78	12	49	1:4.08	1:3.95
23.	12	48	1:4	12	49	1:4.08	1:4.04
24.	13	52	1:4	13	53	1:4.07	1:4.03
25.	12	48	1:4	11	44	1:4	1:4

AB= distance between inferior border of mandible to lower edge of mental foramen.

AC= distance between inferior border of mandible to the occlusal plane.

All measurements are in mm.

TABLE- II

Basic data showing the measurements derived from radiographs of dentulous subjects -females

NO.	MEASUREMENTS						
	RIGHT		PROPORTION	LEFT		PROPORTION	AVERAGE PROPORTION
	AB	AC	AB:AC	AB	AC	AB:AC	
1.	12	48	1:4	12	48	1:4	1:4
2.	11	44	1:4	11	41	1:3.72	1:3.86
3.	10	46	1:4.6	11	46	1:4.19	1:4.4
4.	11	41	1:3.72	11	41	1:3.72	1:3.72
5.	10	42	1:4.2	10	41	1:4.1	1:4.15
6.	12	48	1:4	12	49	1:4.08	1:4.04
7.	11	45	1:4.09	12	45	1:3.75	1:3.95
8.	11	44	1:4	11	42	1:3.81	1:3.90
9.	13	50	1:3.84	12	48	1:4	1:3.9
10.	10	40	1:4	10	40	1:4	1:4
11.	11	42	1:3.81	11	40	1:3.63	1:3.72
12.	12	42	1:3.50	11	42	1:3.81	1:3.65
13.	11	44	1:4	11	44	1:4	1:4
14.	13	49	1:3.76	11	43	1:3.9	1:3.85
15.	11	43	1:3.90	11	43	1:3.90	1:3.90
16.	12	42	1:3.50	11	41	1:3.72	1:3.61
17.	10	41	1:4.1	11	42	1:3.8	1:3.95
18.	9	36	1:4	9	38	1:4.2	1:4.1
19.	11	42	1:3.80	11	43	1:3.90	1:3.85
20.	12	46	1:3.83	11	45	1:4.09	1:3.96
21.	11	47	1:4.27	11	45	1:4.09	1:4.15
22.	11	43	1:3.9	12	46	1:3.83	1:3.85
23.	12	45	1:3.75	11	45	1:4.09	1:3.92
24.	11	42	1:3.8	11	42	1:3.8	1:3.8
25.	12	43	1:3.58	12	43	1:3.58	1:3.58

AB= distance between inferior border of mandible to lower edge of mental foramen.

AC= distance between inferior border of mandible to the occlusal plane.

All measurements are in mm.

TABLE-III

Basic data showing the measurements derived from radiographs of edentulous subjects - males

NO.	MEASUREMENTS						
	RIGHT		PROPORTION	LEFT		PROPORTION	AVERAGE PROPORTION
	A'B'	A'C'	A'B':A'C'	A'B'	A'C'	A'B':A'C'	
1.	12	44	1:3.66	12	44	1:3.66	1:3.66
2.	12	52	1:4	13	52	1:4	1:4
3.	12	47	1:3.91	12	45	1:3.75	1:3.85
4.	11	44	1:4	11	46	1:4.18	1:4.1
5.	14	53	1:3.78	12	50	1:4.1	1:4
6.	13	50	1:3.84	13	50	1:3.84	1:3.84
7.	14	54	1:3.85	14	52	1:3.74	1:3.79
8.	11	44	1:4	13	43	1:3.30	1:3.65
9.	16	46	1:3.50	14	54	1:3.85	1:3.67
10.	14	46	1:3.28	11	43	1:3.90	1:3.59
11.	10	41	1:4.10	11	42	1:3.81	1:3.95
12.	15	58	1:3.86	14	56	1:4	1:3.95
13.	12	46	1:3.83	12	48	1:4	1:3.91
14.	13	47	1:3.61	13	47	1:3.61	1:3.61
15.	11	48	1:4.36	12	47	1:3.91	1:4.15
16.	13	47	1:3.61	12	49	1:4.08	1:3.84
17.	12	48	1:4	12	48	1:4	1:4
18.	11	42	1:3.81	11	43	1:3.90	1:3.85
19.	13	52	1:4	13	52	1:4	1:4
20.	13	50	1:3.84	13	48	1:3.69	1:3.75
21.	12	48	1:4	13	50	1:3.84	1:3.92
22.	14	50	1:3.57	14	50	1:3.57	1:3.57
23.	14	48	1:3.42	12	43	1:3.58	1:3.50
24.	12	48	1:4	11	42	1:4.27	1:4.15
25.	14	51	1:3.64	14	51	1:3.64	1:3.64

A'B' = distance between inferior border of mandible to lower edge of mental foramen.

A'C' = distance between inferior border of mandible to the occlusal plane.

All measurements are in mm.

TABLE-IV

Basic data showing the measurements derived from radiographs of edentulous subjects -females

NO.	MEASUREMENTS						
	RIGHT		PROPORTION	LEFT		PROPORTION	AVERAGE PROPORTION
	A'B'	A'C'	A'B':A'C'	A'B'	A'C'	A'B':A'C'	
1.	12	46	1:3.83	12	43	1:3.58	1:3.70
2.	10	41	1:4.10	10	40	1:4	1:4.05
3.	10	40	1:4	11	44	1:4	1:4
4.	12	50	1:4.16	13	48	1:3.69	1:3.95
5.	12	47	1:3.91	12	48	1:4	1:3.95
6.	13	47	1:3.6	13	46	1:3.53	1:3.55
7.	11	45	1:4.09	11	42	1:3.82	1:3.95
8.	11	44	1:4	11	43	1:3.90	1:3.95
9.	10	42	1:4.20	11	42	1:3.83	1:4
10.	12	43	1:3.58	11	43	1:3.83	1:3.75
11.	11	45	1:4.09	12	46	1:4	1:3.96
12.	12	47	1:3.91	12	46	1:4	1:3.85
13.	11	44	1:4	10	40	1:3.33	1:4
14.	12	46	1:3.83	11	44	1:4	1:3.9
15.	8	33	1:4.12	9	30	1:4	1:3.72
16.	12	48	1:4	12	48	1:3.69	1:4
17.	12	48	1:4	12	48	1:3.75	1:4
18.	12	46	1:3.83	13	48	1:4.09	1:3.76
19.	12	44	1:3.66	12	45	1:4	1:3.75
20.	12	45	1:3.75	11	45	1:3.75	1:3.92
21.	11	46	1:4.18	11	44	1:3.73	1:4.09
22.	12	45	1:3.75	11	45	1:3.73	1:3.75
23.	11	41	1:3.73	11	41	1:3.73	1:3.73
24.	11	41	1:3.73	11	41	1:3.73	1:3.73
25.	12	48	1:4	12	48	1:4	1:4

A'B'= distance between inferior border of mandible to lower edge of mental foramen.

A'C'= distance between inferior border of mandible to the occlusal plane.

All measurements are in mm.

TABLE-V

COMPARISION OF THE MEAN PROPORTION BETWEEN DENTULOUS AND EDENTULOUS SUBJECTS

GROUP	NO.	PROPORTION				SIGN. OF DIFFERENCE		
		Range	Mean	SD	SE	Diff.	t-value	p-value
Dentulous	50	3.53-4.40	3.90	0.17	0.02	0.06	1.50	0.14 NS
Edentulous	50	3.50-4.15	3.84	0.18	0.03			

SD= Standard deviation

SE= Standard error of difference

t-value= unpaired t- test

P<0.05=S (SIGNIFICANT)

P>0.05=NS (NON-SIGNIFICANT)

TABLE- VI

COMPARISION OF THE MEAN PROPORTION BETWEEN DENTULOUS AND EDENTULOUS MALE SUBJECTS.

GROUP	NO.	PROPORTION				SIGN. OF DIFFERENCE		
		Range	Mean	SD	SE	Diff.	t-value	p-value
Dentulous	25	3.53-4.40	3.89	0.16	0.03	0.05	1.18	0.24 NS
Edentulous	25	3.50-4.15	3.84	0.14	0.04			

TABLE-VII

COMPARISION OF THE MEAN PROPORTION BETWEEN DENTULOUS AND EDENTULOUS FEMALE SUBJECTS

GROUP	NO.	PROPORTION				SIGN. OF DIFFERENCE		
		Range	Mean	SD	SE	Diff.	t-value	p-value
Dentulous	25	3.58-4.40	3.91	0.18	0.04	0.04	0.91	0.36 NS
Edentulous	25	3.55-4.10	3.87	0.14	0.03			

TABLE-VIII

COMPARISION OF THE MEAN PROPORTION BETWEEN DENTULOUS MALE AND FEMALE SUBJECTS

GROUP	NO.	PROPORTION				SIGN. OF DIFFERENCE		
		Range	Mean	SD	SE	Diff.	t-value	p-value
Male	25	3.53-4.40	3.89	0.14	0.03	0.02	0.30	0.77 NS
Female	25	3.58-4.40	3.91	0.18	0.04			

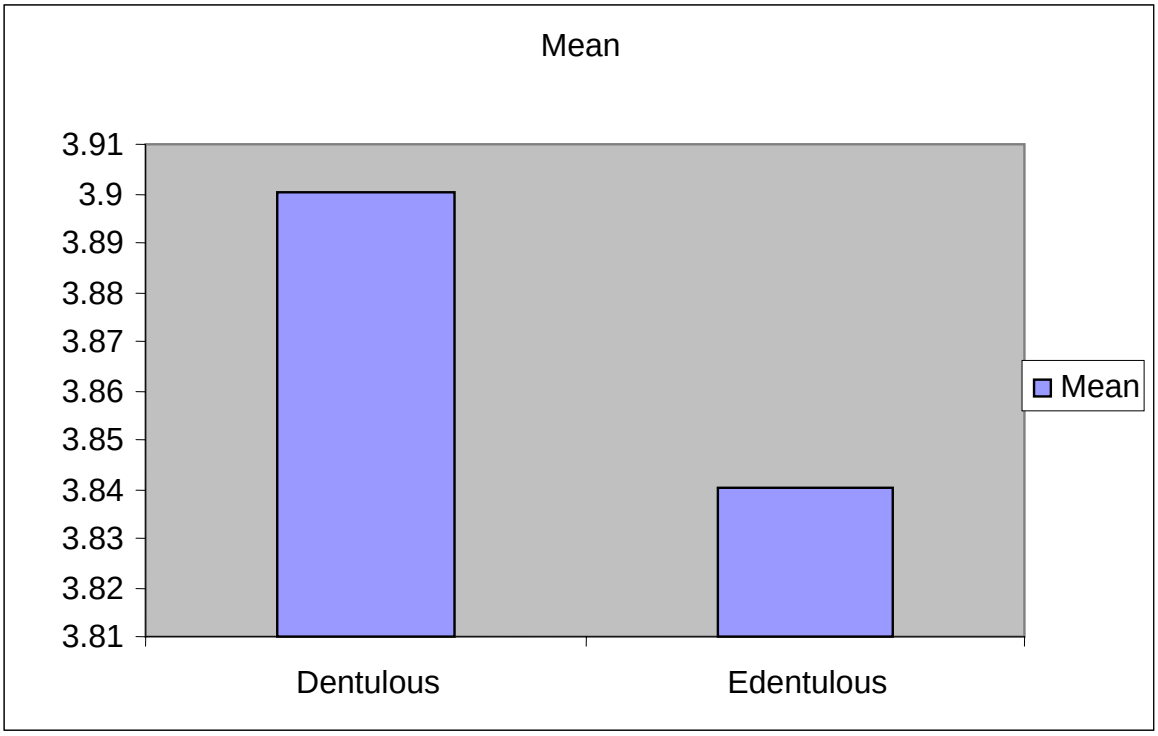
TABLE-IX

COMPARISION OF THE MEAN PROPORTION BETWEEN EDENTULOUS MALE AND FEMALE SUBJECTS

GROUP	NO.	PROPORTION				SIGN. OF DIFFERENCE		
		Range	Mean	SD	SE	Diff.	t-value	p-value
Male	25	3.50-4.15	3.84	0.19	0.04	0.03	0.67	0.51 NS
Female	25	3.55-4.10	3.87	0.14	0.03			

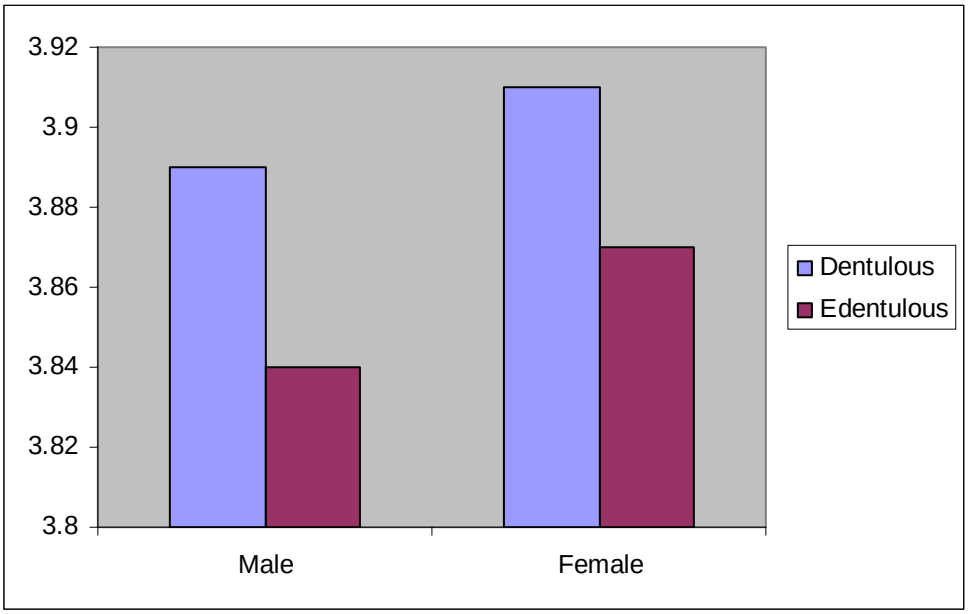
GRAPH – I

Comparison of the mean proportion between dentulous and edentulous subjects (without sex differentiation)



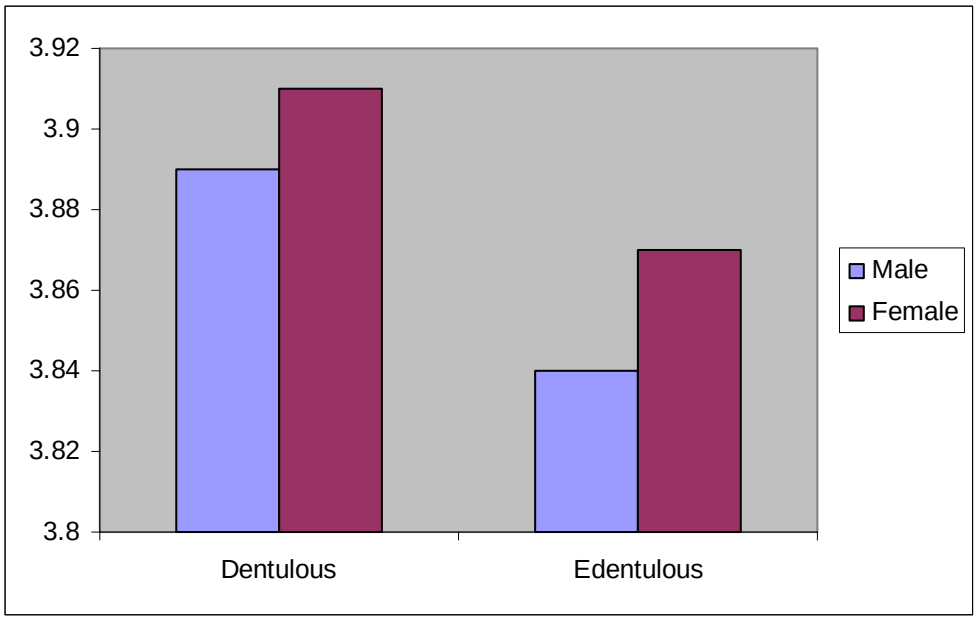
GRAPH- II

Comparison of the mean proportion between dentulous and edentulous subjects (with sex differentiation)



GRAPH III

Comparison of the mean proportion between male and female subjects within Dentulous and Edentulous subjects



Discussion

Discussion

Most prosthodontic text books advise that artificial teeth be placed in the positions previously occupied by the natural teeth.[35] The natural teeth occupy a zone of equilibrium, with each tooth assuming a position that is the resultant of all the various forces acting on it. This is usually a stable position unless actual changes in the dentition have occurred. When natural teeth are to be replaced by artificial teeth, it is logical to arrange the artificial teeth in a position as close as possible to the one previously occupied.[6] This is particularly true of the plane of occlusion: a feature that plays an important role in fulfilling the criteria of both function and esthetics.

Since tooth loss and subsequent prosthetic reconstruction in no way affect the maxillary plane, it is considered preferable to relate the occlusal plane to the maxillary rather than to the mandibular plane. Although the mandibular plane may also be independent of the existence of the dentoalveolar structures, the mobile nature of the mandible renders the orientation of the mandibular plane infinitely variable in relation to craniofacial skeletal landmarks.[31] The location of the plane of occlusion is not totally an arbitrary determination but is based on anatomic structures, jaw movements and mechanics. The potential for the buccinator muscle and the tongue to aid in lower denture stability is influenced by the location of the mandibular teeth, which in turn depends upon the position of the lower occlusal plane.

From the functional viewpoint, the occlusal table is a milling surface, strategically placed so that the tongue on the lingual side and the buccinator muscle on the buccal side are able to position the food bolus onto it and hold it there while mastication takes place. Faulty orientation of the occlusal plane in removable or fixed

prostheses will jeopardize this interaction between tongue and buccinator muscle and result at one extreme in food collection in the sulcus, and at the other extreme in biting of the check or tongue.

Biting force during maximum clenching was observed to be the greatest when the occlusal plane was made parallel to the ala- tragus line and decreased when the occlusal plane was inclined about 5 degrees anteriorly or about 5 degrees posteriorly.[39]

The correct orientation of the occlusal plane plays a vital role in optimal esthetic achievement. In the natural smile, the incisal tips follow the curve of the lower lip. This effect is an expression of a correctly orientated occlusal plane; if the plane hangs posteriorly, the lip- line viewed from the front will appear straight and contribute more than any other factor to the so- called "denture look". With the occlusal plane correctly orientated, however, the natural anterior curve will be achieved almost automatically and contribute a proper sense of perspective to the dental composition. Accurate orientation of the occlusal plane is important for the stability, phonation, esthetics and function of the denture.

Many theories have been postulated over the years as to how orientation of the occlusal plane might best be established.

The use of pre-extraction records to achieve the plane of occlusion in edentulous patients has been advocated for many years, with many methods proposed for making them. Among these methods are special gauges (e.g., Sorenson, [10] Willis, [63] Dakometer, [14]) cardboard or wire profiles, [30, 53 64] measurements from photographs, [53, 60, 65] measurement of the interfrenal distance, [58] measurement of the closest speaking space, [45] and use of a gauge oriented on the palate to reproduce tooth position.[18] However the use

of these records for the orientation of occlusal plane in edentulous patients is not uniformly accepted.

In the absence of previous records investigators[2,19,21] have suggested various concepts or methods for the orientation of the occlusal plane based on morphologic studies on natural and artificial dentitions and also on clinical judgment Broadly these methods can be classified as intra oral or extra oral for orientation of the occlusal plane in edentulous patients. Extra oral methods for the orientation of occlusal plane continue to dominate over the intra oral methods for its ease of manipulation and external visibility at all times, especially for the less experienced dentists when the maxillary wax rim is trimmed to the occlusal plane. Out of all the proposed extra oral methods for orientation of the occlusal plane in edentulous patients, ATL continues to be the most widely used and well documented guide for occlusal plane orientation.[25]

Tragus of the ear is associated in prosthodontic practice as a landmark to establish occlusal plane and to locate the arbitrary hinge axis point. Nevertheless, it is controversial as to which part of the tragus should be taken as a reference for these two lines. The anatomical configuration of the tragus of the ear is variable. Further the several tragal references recommended in the literature are not always definable or recognizable.[48]

Clapp[8] in 1910 was the first to relate Camper's line/plane to occlusal plane. Since then various tragal references have been suggested to denote which part of the tragus should be taken to develop the ala-tragus line. Three tragal references are commonly recommended to obtain the ala-tragus line. These are the superior border,[20, 56]

[64], middle or tip[22 56, 68] and the inferior margin or border of the tragus[19, 37]. It is not known whether these observations are personal preferences or those based on investigations, however between the seven tragal references selected to orient ala-tragus plane to occlusal plane, parallelism was seen when the tragal reference was between superior border and the middle of the tragus (41.5%).[49]

Definitions of the ala-tragus line cause confusion, because the exact points of reference do not agree. For example, the Glossary of Prosthodontic Terms (2005, eighth edition) states that the ala-tragus line runs from the inferior border of the ala of the nose to some defined point on the tragus of the ear, usually considered to be the tip of the tragus, while Spratley[51] describes it as running from the center of the ala to the center of the tragus; whereas Ismail and Bowman[21] define it as a line that passes from the ala of the nose to the center of the tragus of the external auditory meatus. It was also found that the tragus had several morphological variations and the middle of the tragus or the preciseness of superior border and inferior border was not always definable. Therefore its validity as a reference point has been questioned. [48]

It is also necessary to ascertain that the selected reference points are not affected by degenerative processes or surgical interference and could readily be identified on the face.[46] An investigation in edentulous subjects showed that there was no appreciable change in the basic types of tragus morphology and the three distinct shapes of the superior border of tragus. However, chronological senile changes were observed as vertical lines in the skin in front of the tragus and the other senile change noticed was the profuse hair growth along the borders of the tragus mostly in the inferior and middle border in male subjects usually above 50 years. The profuse hair growth in tragus also renders it cumbersome to identify and mark the various tragal landmarks. [50]

The use of cephalometrics in Prosthodontics has been advocated for some time and its introduction into prosthetic treatment planning has become evident, and attempts have been made to establish cephalometric norms.[31] However, its use in determining or evaluating the position and inclination of the occlusal plane has given conflicting results: L'Estrange and Vig (1975) found a correlation between the orientation of the occlusal and maxillary planes in two groups of subjects, one dentate(25-35 years) the other edentulous(36-78 years). Sloane and Cook (1953) found an inverse correlation between the length of the maxillary plane and the inclination of the occlusal plane.Monteith (1985a, b, 1986) postulated a relationship between the anterior Porion- Nasion-Anterior Nasal Spine (Po N Spna) and the angle between the Frankfort plane and the occlusal plane, and proposed a mathematical formula to calculate the inclination of the cephalometrically determined occlusal plane in the articulator. Karkazis and Polyzois (1991) applied Montheit's formula to two groups of subjects, dentulous and edentulous and failed to get the same results. There is a lack of consensus among various authors as to the reliability of cephalometrics in establishing the occlusal plane for edentulous subjects and it would also necessitate an additional radiograph for all such cases, since it is rarely used for diagnostic purposes in edentulous patients.

In contrast to this Panoramic radiography is widely used and is often a tool used in routine dental examinations, especially for edentulous patients before the construction of a complete denture and implant selection.[17] It is also a convenient radiologic approach to survey dental condition by providing information about most aspects of dentistry with only one panoramic film. Assessing residual ridge resorption, positions of maxillary sinus, mandibular canal

and mental foramen with panoramic radiographs is practical for examination of large samples of patients. Panoramic radiography is commonly used in large institutional practices as the sole method of screening edentulous and dentate patients.[1] This modality is probably the most utilized diagnostic modality in implant dentistry.

Many reports have concluded that the radiographic screening of all edentulous patients is indicated because of the considerable percentage of positive radiographic findings.[3, 4, 7,9,11, 19, 20, 23, 27.] A slight misalignment of the head does not significantly affect the vertical measurements in the mandible or of the posterior maxilla if the reference lines are in the same vertical plane as the teeth.[66] H. Tal and O.Moses compared the accuracy of panoramic radiography and computed tomography (CT) in the evaluation of depth of the mandible at recipient implant sites.[54] Measurement of the vertical bone depth was found in this study to be sufficiently accurate whether using panoramic radiography or CT. Although the latter proved statistically superior, differences of less than 1mm are of insufficient clinical significance to justify its routine use. In spite of these merits there is insufficient data on the use of panoramic radiographs for the evaluation and determination of the occlusal plane in edentulous individuals.

In light of the above, the present study was undertaken to investigate the role of panoramic radiography in assessing, evaluating and comparing the occlusal plane in a selected group of dentulous and edentulous subjects of Indian origin. The rationale behind the present study was to measure the distances between the inferior border of the mandible, lower edge of the mental foramen and the occlusal plane in a selected group of dentulous subjects. This was to derive a proportion between the measured distances relating the inferior border of the mandible to the lower edge of the mental foramen and

inferior border of the mandible to the occlusal plane in dentulous subjects. The obtained proportion was used to compare and correlate with the proportions obtained in edentulous subjects for whom the occlusal plane was oriented using the ala tragal reference line. The objective was to assess the feasibility of such a proportion for establishing the occlusal plane for edentulous subjects with the aid of panoramic radiographs.

An equal number of male and female subjects were selected in the dentulous and edentulous categories to investigate any sexual variation in the proportions obtained. The lower edge of the mental foramen and the inferior border of the mandible were chosen as reference points for both test groups since it is known to remain constant in spite of increasing age or resorption of the alveolar process above the foramen. [43,33,15,55,]The bone below the foramen constitutes a predictable proportion of the total bone height in the majority of normal subjects and has been shown not to be significantly affected by resorption until extreme atrophy occurs, its height might serve as the basis for estimating the original mandibular height in edentulous subjects. [61]

Clinically the lower edge of the mental foramen appears to be a more useful reference mark in panoramic radiographs [61] .Hence in the present study, the inferior border of the mandible and the mental foramen were considered as the reference points for deriving the required proportions.

It has been stated that the most common location of the mental foramen was inferior to the crown of the second premolar and approximately 60% of the distance from the buccal cusp tip of that tooth to the inferior border of the mandible.[41] And also in the natural dentition, the lower occlusal plane runs from the incisal edges of the lower anterior teeth through the tips of the cusps of the posterior teeth to a point approximately two thirds of the height of the retromolar pad.[32] Further

according to a study by Xie *et al,* if reference lines and measured points are located in the same vertical plane or in approximately the same plane as the teeth, variations in vertical measurements in the mandible and the posterior regions of the maxilla fall within a small range. According to them vertical measurements should only be made using reference points and lines that are located anatomically directly above or below the point being measured, in the plane as the centre of the image layer.[66] Based on the above recommendations in the present study the lower occlusal plane was considered at or closer to the lower second premolar in the dentulous subjects depending upon the location of the mental foramen.

Comparative studies on dry skulls have shown a close correlation with the radiographic location of the mental foramina. [16,41,44, ,59, 69] Since the clinical and radiological locations of mental foramina bear a strikingly close resemblance, the selection of the mental foramina as a reference point has some validity and hence measurements done from panoramic radiographs can be related clinically to oral environment.

The fabricated occlusal rims were adjusted anteriorly as per esthetics, visibility and parallelism with the interpupillary line. Posterior occlusal plane was made parallel to the ATL and was verified by the fox plane. According to E. G.R. Solomon et a1.[49], Camper's plane (ala-tragus line) was found to be parallel to the occlusal plane when the tragal reference point was situated between the superior border and middle of the tragus and not from the usual recommended reference points, therefore the tragal reference in the present study was chosen to be in between the superior border and middle of the tragus. It can also be stated that the validity of the ATL in determining the posterior occlusal plane in edentulous patients still holds true when the junction of the

superior and middle part of tragus of the ear and lower border of the ala of the nose are used as reference points for the ATL as confirmed in this study.

To avoid interexaminer error, only one investigator was responsible for performing all the measurements for all the subjects. A.U. Guler et al[17] in a study on variation in the vertical height measurements in the edentulous maxilla and mandible had used proportions derived from dentulous subjects to arrive at the measurement sites in edentulous subjects using panoramic radiographs. The measurements of various anatomic landmarks from the crest of the ridge were calculated for e.g. at the molar and premolar sites. To derive at the location of molar and premolar sites in edentulous patients they used the proportions of the horizontal distances of these sites from the midline of dentulous patients. The authors were of the view that the measurement sites in the edentulous mandible could be determined with these proportions obtained from the dentate patients' radiograph, while the same panoramic machine was used in both groups, and no obvious distortion was observed in the images of the maxillas and mandibles.[17] They also stated that magnification factor was not necessary to correct the radiographic heights, because all radiographs were taken with the same panoramic apparatus.

On the basis of the above, present study used proportions derived separately for dentulous and edentulous subjects from their respective panoramic radiographs and were later correlated and comparisons were drawn. Hence, the obtained proportion between the inferior border of the mandible to the lower edge of the mental foramen and between the inferior border of the mandible to the dentulous occlusal plane can be convincingly used to predict the height of the occlusal plane in edentulous patients from the inferior border of the mandible, if a similar proportion existed for the edentulous subjects also.

The present study was an attempt to establish a proportion in the distances between the inferior border of mandible to lower edge of mental foramen (AB) and inferior border of mandible to occlusal plane (AC). These distances for dentulous and for edentulous subjects were determined by measuring them on traced panoramic radiographs. A similar study was conducted by Wical and Swoope[61] to establish a proportion in the distance between the total height of the mandible and the height of the lower edge of the mental foramen and upper edge of mental foramen to the inferior border of mandible. The measurements were done on panoramic radiographs of the dentulous subjects. The mean ratio between the total height of the mandible and the height of the lower edge of the foramen was 2.90:1, the mean ratio between the total height of the mandible and the height of the upper edge of the foramen was 2.34: 1. By observing the distance from the inferior border of the mandible to the lower edge of the foramen and using the approximate ratio of 3:1, the original height of bone was predicted to be approximately three times the height of the bone between the inferior border of the mandible and the lower edge of mental foramen.

Similarly, in the present study using the inferior border of mandible, mental foramen and occlusal plane as references, a proportion was established between the inferior border of mandible to the lower edge of the mental foramen and inferior border of mandible to the occlusal plane in dentulous and edentulous subjects. The mean proportion for dentulous subjects was 1:3.90. The overall mean proportion for edentulous subjects was 1:3.84. The mean proportions for male dentulous and male edentulous subjects were 1:3.89 and 1:3.84 respectively which was statistically insignificant. The mean proportions for female dentulous and female edentulous subjects were 1:3.91 and

1:3.87 respectively, which was again statistically insignificant. On overall comparison between the dentulous and edentulous subjects, the difference calculated was also statistically insignificant

The average distance between the cusp tip and the superior border of the mental foramen by direct measurement was 23.42 mm and 25.69 mm in the panoramic view. The mean distance between the superior border of the mental foramen and the bottom of the mandible was 14.33 mm by direct measurement and 16.52 mm by radiographic measurements in an earlier study by Kim In Soo et al. In the present study although the lower border of the mandible was considered as a reference point and considering that the diameter of the mental foramen as reported by Phillips was about 3.5mm in vertical aspect, the measurements in the present study were almost within the same range as reported in the earlier study by Kim In Soo et al. The inferior border of the foramen was usually 11.5 to 16.0mm from the inferior border of the mandible.[41] Measurements in the present study also fell within the same range.

Wical and Swoope in their study obtained a proportion of 1:2.90; they considered it approximately as 1:3 to measure the original height of the alveolar bone. In this study a mean proportion of 1:3.90 and 1:3.84 were obtained in dentulous and edentulous subjects. This proportion can be approximately considered as 1:4.

The findings of this study showed that the lower occlusal plane in edentulous subjects was almost at the same level with that of the dentulous subjects. Thus the ratio of 1: 4 can be used to establish the level of lower occlusal plane in edentulous subjects by measuring the distance between the lower edges of mental foramen to inferior border of mandible on the diagnostic panoramic radiograph itself at an earlier treatment planning stage.

Since this ratio is obtained from the panoramic radiograph using the anatomic reference points it can be of special help in those patients where panoramic radiographs were used as a diagnostic modality. Since the present study uses radiographic reference points for the location of occlusal plane, it can be uniformly applied to all patients with considerable ease.

Also of special mention, is the fact that the predictability of implant treatment has transformed treatment methodology for edentulous patients, be it an implant supported overdenture or implant supported fixed prostheses. The height of the occlusal plane from the crest of the ridge can be of special help in the selection of the implant superstructure and various components involved in such treatment procedures during treatment planning.

The present study had its own limitations and there is always a scope for future enhancement. In some instances the mental foramen is not distinctly visible on the panoramic radiographs. Various reasons have been sited for its conspicuous absence in the literature; some amongst them include superimposition of tooth buds in mixed dentition radiographs, inability to distinguish from the trabecular pattern in complete dentition radiographs, thin mandibular bone in edentulous radiographs, and overly dark radiographs.[69] Recent studies have questioned the constancy of the mental foramen and the inferior border of the mandible with increasing duration of edentulism but nothing conclusive has yet been put forward on this aspect. Additional studies are needed to validate this fact and draw more convincing conclusions.

Occasionally unreadable or grossly distorted images maybe encountered in the panoramic radiographs wherein it may be difficult to carry out this procedure. Repeated radiographs have to be taken in such situations. With the advent of digital

panoramic radiography yielding sharper and less distorted images, this technique may be of enhanced value. Further studies with a bigger sample size are needed to prove the validity of the obtained proportion in predicting the height of the occlusal plane in edentulous patients using the proportion that was obtained from dentulous subjects.

Conclusion

CONCLUSION

The following conclusions were drawn from the present clinical study, which evaluated and compared radiographically the proportion in the distances between the inferior border of the mandible to the lower edge of mental foramen and inferior border of mandible to the occlusal plane in dentulous and edentulous subjects:

1. A proportion of 1:4 was established for the distances between the inferior border of the mandible to the lower edge of mental foramen and the inferior border of the mandible to the occlusal plane for all the fifty dentulous subjects included in this study.
2. A similar proportion of 1:4 was established for the distances between the inferior border of mandible to the lower edge of the mental foramen and the inferior border of the mandible to the occlusal plane for all the fifty edentulous subjects included in this study.
3. The mandibular occlusal plane derived for edentulous subjects yielded a plane of occlusion similar to that of dentulous subjects in this study.
4. The derived proportion of 1:4 between the inferior border of mandible and mental foramen and inferior border of mandible and occlusal plane in edentulous patients as measured on an orthopantogram may yield a plane of occlusion similar to that existing in the dentulous state.

Summary

SUMMARY

This study radiographically evaluated and compared the proportion between the inferior border of the mandible to the mental foramen and inferior border of the mandible to the occlusal plane in dentulous and edentulous subjects on panoramic radiographs. Fifty dentulous and fifty edentulous subjects who fulfilled the selection criteria were selected for the study.

Panoramic radiographs were obtained of the selected dentulous patients and were traced to outline the selected reference points, namely inferior border of the mandible, mental foramen, and the occlusal plane. Distances were measured between the selected reference points and a proportion was derived between the inferior border of the mandible to the lower edge of the mental foramen and inferior border of the mandible to the occlusal plane in dentulous subjects.

In edentulous subjects a similar procedure was performed to obtain proportions between the same reference points. The maxillary occlusal rims were oriented anteriorly using the inter-pupillary line as reference and posteriorly using the ala-tragus line as the reference. A stainless steel wire was attached to the mandibular occlusal rim once the jaw relations were recorded, to aid in the location of occlusal plane radiographically. The results obtained were tabulated and subjected to statistical analysis.

A proportion of 1:4 was obtained radiographically between the distances measured between the inferior border of the mandible and lower edge of mental foramen and between the inferior border of mandible and the occlusal plane in all the selected fifty dentulous subjects. A similar proportion of 1:4 was obtained in edentulous patients between the same reference points when the occlusal rims were oriented using inter-

pupillary line anteriorly and ala-tragus line posteriorly in all the selected fifty edentulous subjects included in this study.

The above drawn proportion between the inferior border of the mandible to the lower edge of the mental foramen and between the inferior border of the mandible and the occlusal plane in edentulous patients may yield a plane of occlusion which is oriented similar to that existing in the dentulous state. The proportions derived radiographically in this study can serve as a basis for future studies to establish the occlusal plane for edentulous subjects.

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